



## Original Research

# The Dynamics of Serum Lipid and Lipoprotein Profiles in Growing Foals



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## ABSTRACT

The neonatal period is a transitional phase between the fetal and newborn functions during which homeostatic mechanisms complete their maturation allowing the foal's adaptation to extrauterine life. Knowledge of these physiological conditions in newborn foals establishes the basis of their management and has important implications in health and welfare. This study aimed to evaluate the changes in lipid parameters in eight healthy full-term foals during the first month of life. From each animal, blood samples were collected every 3 days from day 1 until day 30 of life and were tested for serum total lipids, phospholipids, triglycerides, total cholesterol (total chol), high-density lipoprotein cholesterol (HDL chol), low-density lipoprotein cholesterol (LDL chol), very low-density lipoprotein cholesterol (VLDL chol). One-way repeated measures analysis of variance was applied to determine the effect of days of life on studied parameters. Significant effect of days of life was found on serum total lipids ( $P < .01$ ), triglycerides, total chol, HDL chol, LDL chol ( $P < .05$ ), and VLDL ( $P < .01$ ). The changes in serum lipids and lipoproteins levels found in the present study could represent a response to metabolic adaptations occurring during neonatal period to ensure a better utilization of energy sources by newborn animal. Our results enhance the knowledge about the lipid profile in growing foals providing new information that could be useful in clinical practice to assess foals suffering from disease.

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## 1. Introduction

Every breeding farm hopes for an uneventful foaling season, a high percentage of live births, and strong foals that remain healthy and grow well. Regardless of management, however, every farm has to deal with foal illness from time to time. Detecting health problems and getting the sick foal into a program of veterinary care must be done quickly to ensure the best outcome. The neonatal period is a critical stage, and the offspring has to face several

adjustments to adapt the body systems to extrauterine life. The time during which these changes take place is known as the adaptive period, and it begins at birth and extends until the 30th day of life [1,2]. At this time, foals are metabolically instable and susceptible to a number of both congenital and acquired diseases, which can compromise the health conditions of the newborn and its odd of surviving [1,3–6].

The major adaptation of the newborn is the change from placental nutrition to alimentation. At birth, the oral nutrient intake becomes the only source of nutrition. Colostrum is not only a valuable source of nutrients but also abounds in bioactive compounds such as: immunoglobulins, peptides, hormones, growth factors, nucleotides, and enzymes.

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Several studies carried out on newborn calves have shown that colostrum and milk ingestion, both considered as a rich source of fat, cause gradual increase in total cholesterol (total chol), high-density lipoprotein cholesterol (HDL chol), and low-density lipoprotein cholesterol (LDL chol) and triglyceride concentrations during the first week of life [7–9]. Changes in the serum concentrations of cholesterol and triglycerides have also been reported in newborn foals [10]. It is reported that neonatal foals could be subjected to hypertriglyceridemia [11,12]. In veterinary clinical practice, hyperlipemia is considered the primary cause of disease in about 20% of cases studied by Watson et al [13] and the mortality rate induced by this pathologic condition is approximately 65% [14].

Therefore, the monitoring of serum lipid profile in newborn foals will be helpful for a more accurate diagnosis and may be applicable to the results of preventive medicine. However, in the available literature, there is a lack of information concerning the changes of serum lipids and lipoprotein values of foals in response to dynamic adaptation processes characterizing the early postnatal period.

In view of this, the aim of this study was to investigate the dynamic changes of serum lipid and lipoprotein profiles in newborn foals during the first month of life.

## 2. Material and Methods

Eight Italian Saddle breed full-term foals (five females and three males) born in the same breeding center located in Sicily (latitude 37.46 N; longitude 14.93 E) were enrolled in this study with the informed owner consent.

Foals were kept in individual boxes with their dams under natural environmental conditions (min temperature of 8.5°C; max temperature of 20.4°C; relative humidity of 68.2%) and moved to paddocks (no grass available) during the day (10 AM–4 PM). Foals were fed only with colostrum and maternal milk.

The dams received 6.0 ± 1.0 kg/d dried grass hay (crude protein 9%, crude fiber 35%, Ca 0.4%, P 0.23%) and 5 ± 0.5 kg/d commercially available concentrates (crude protein 16%, crude fat 6%, crude fiber 7.35%, ash 10.09%, Ca/P 1.5:1, Na 0.46%, lysine 0.85%, methionine 0.35%, omega-3 0.65%).

At birth, each foal was subjected to a complete physical examination performed by the same veterinarian, and routine hematology as well as plasma biochemistry were carried out. The foals included in the study were considered healthy at clinical examination.

Body weight of each foal was measured at days 1 and 30 after birth by a means of a mobile weighing platform (Goodwood scales, Horse Weigh, UK).

The same operator performed blood sampling from each foal by jugular venipuncture into vacutainer tubes (Terumo Corporation, Tokyo, Japan) without anticoagulant agent every 3 days starting from day 1 (after colostrum intake) until day 30 of life.

After standing at room temperature for 20 minutes, the tubes were centrifuged at 3,000 rpm for 10 minutes and the obtained sera were stored at –20°C until analyzed.

The not hemolyzed obtained sera were analyzed by means of an automated analyzer UV Spectrophotometer (model Slim SEAC, Florence, Italy) using commercially available kits, to assess the concentration of total lipids, phospholipids, triglycerides, total chol, HDL chol, and LDL chol. Very low-density lipoprotein cholesterol (VLDL chol) was estimated as one-fifth of the concentration of triglycerides [15].

Protocols of animal husbandry and experimentation were reviewed and approved in accordance with the standards recommended by the Guide for the Care and Use of Laboratory Animals and Directive 2010/63/EU for animal experiments.

### 2.1. Statistical Analysis

All data are expressed as mean values ± standard deviation (SD).

The statistical elaboration of the data obtained for each parameter was based on the average values obtained. Data were normally distributed ( $P > .05$ , Kolmogorov–Smirnov test).

One-way repeated measures analysis of variance (ANOVA), followed by Bonferroni post hoc comparison test, was applied to determine statistical effect of days of life on studied parameters.  $P$  values <.05 were considered

**Table 1**

Mean values ± SD (standard deviation) of serum total lipids, phospholipids, triglycerides, total cholesterol (total chol), high-density lipoprotein cholesterol (HDL chol), low-density lipoprotein cholesterol (LDL chol), and very low-density lipoprotein cholesterol (VLDL chol) in eight growing foals during the first month of life.

Days of Life	Total Lipids (mg/dL)	Phospholipids (mg/dL)	Triglycerides (mg/dL)	Total Chol (mg/dL)	HDL Chol (mg/dL)	LDL Chol (mg/dL)	VLDL Chol (mg/dL)
1	549.26 ± 78.12	226.19 ± 34.59	101.81 ± 8.30	216.88 ± 16.79	74.95 ± 3.41	96.98 ± 4.55	20.36 ± 1.66
3	550.14 ± 45.58	257.20 ± 30.28	100.37 ± 7.15	200.74 ± 13.53	73.78 ± 7.10	97.36 ± 5.98	20.07 ± 1.43
6	530.01 ± 29.78	275.83 ± 60.37	46.41 ± 4.86	196.49 ± 13.02	67.39 ± 8.26	94.37 ± 7.66	9.28 ± 0.68
9	540.24 ± 60.42	276.92 ± 39.08	60.57 ± 7.90	169.37 ± 26.97	63.53 ± 5.03	87.37 ± 9.15	12.11 ± 1.58
12	490.64 ± 34.74	244.10 ± 35.56	51.35 ± 5.17	162.77 ± 29.64	58.69 ± 6.63	80.96 ± 3.06	10.27 ± 1.03
15	489.19 ± 36.73	279.70 ± 77.95	60.21 ± 8.32	167.35 ± 30.88	58.53 ± 11.35	81.28 ± 2.39	12.04 ± 1.66
18	354.10 ± 55.58	255.90 ± 98.28	48.59 ± 5.95	176.67 ± 40.71	49.56 ± 7.98	82.20 ± 3.23	9.72 ± 1.19
21	355.44 ± 45.38	238.35 ± 38.26	68.00 ± 7.27	178.26 ± 20.38	52.87 ± 2.28	82.56 ± 3.17	13.60 ± 1.45
24	354.96 ± 81.83	221.20 ± 13.10	63.92 ± 7.65	177.23 ± 24.37	56.82 ± 5.80	82.53 ± 2.49	12.78 ± 1.53
27	360.73 ± 75.84	225.59 ± 51.80	53.82 ± 5.00	177.33 ± 23.12	65.04 ± 4.39	82.46 ± 9.39	10.76 ± 1.00
30	359.85 ± 35.37	235.61 ± 78.05	57.19 ± 7.43	178.61 ± 13.77	64.35 ± 5.12	83.02 ± 5.75	11.44 ± 1.49

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